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MEMORANDUM FOR PRS (Contractor Publication)

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L.F. Cannizzo et al. "Utilization of Ammonium Dinitramide (ADN) on Propellant Formulations" (Statement A)

UTILIZATION OF AMMONIUM DINITRAMIDE (ADN) IN PROPELLANT FORMULATIONS*

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ABSTRACT

Utilization of the high energy oxidizer ammonium dinitramide (ADN) gives several desirable characteristics when employed in solid propellants. These include non-chlorine combustion products (attractive for applications where hydrochloric acid might contaminate sensitive payload components), facile extraction into water (suitable for water washout/ingredient recovery and/or reuse demilitarization methods), simple methods for destruction (easily converted into the fertilizer ammonium nitrate), and attractive performance and ballistic characteristics. At Thiokol the viability of ADN as a propellant ingredient has been greatly enhanced by the use of additives to stabilize the material and a prilling process to give spherical, defect-free particle morphology, ideal for propellant formulating. The major technical challenge remaining is to reduce the hazards of propellants which contain ADN as the main oxidizer.

Introduction

One of the current emphasis in further developing solid propellant technology is compatibility with the environment in all phases of the process: manufacturing, use, and demilitarization. Over the last ten years significant process has been made with accomplishments such as waste minimization during manufacturing¹, performing studies to understand the local and global environmental impact of solid propellant combustion², and reuse of demilitarized solid propellant in commercial mining explosives³. Utilization of the new high energy oxidizer ammonium dinitramide

(ADN) enables the formulation of high performance solid propellants that do not produce hydrochloric acid (HCl) in the exhaust, an important development for orbit transfer applications where satellite components may be sensitive to HCl. ADN contributes only nitrogen and water to the exhaust plume, is very soluble in water and can be easily extracted from solid propellants, can be converted into ammonium nitrate (a common fertilizer) in a one step, simple process, and give competitive performance (compared to ammonium perchlorate) in solid propellant formulations. The current status in the development of ADN at Thiokol as a solid propellant ingredient will be discussed in the remainder of this paper.

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ADN Properties

The physical and chemical properties of ADN have a significant impact on its viability of a solid propellant ingredient. These properties are presented in Table 1. The properties of most concern are hygroscopicity, thermal instability, and safety characteristics. Various methodologies have been studied in order to overcome these limitations. At Thiokol the combination of additives and a prilling process has significantly improved these properties (see next section). In addition, other properties, such as high solubility in water and facile decomposition using light, are advantageous in that they permit simple methods to remove and destroy ADN from solid propellants.

Table 1. Selected Chemical and Physical Properties of ADN

chemical/physical property	value
melting point	92-94°C
sensitive to light?	yes
hygroscopic?	yes
water solubility	very high
impact sensitivity	moderate
friction sensitivity	low
thermal decomposition (onset)	160°C (20°C/min)
particle dimensions	long needles
incompatibilities	isocyanates

Prilled ADN

To improve the hygroscopicity, thermal stability, and safety properties of ADN a prilling process was developed at Thiokol under funding from the Navy's ADN MANTECH Program. The proprietary process involves the addition

of additives, before the prilling process, to overcome the shortcomings listed above. Improvements in these properties have been realized and these modified properties are presented in Table 2. Further work is ongoing to seek additional improvements. The major obstacle remaining to ADN employment for booster applications is the current propellant hazards properties of ADN-containing propellants (see the ADN Propellant section of this paper)

Table 2. Selected Chemical and Physical Properties of Thiokol Prilled ADN

chemical/physical property	value
melting point	92-94°C
sensitive to light	yes
hygroscopic	no
water solubility	very high
impact sensitivity	low to moderate
friction sensitivity	low
thermal decomposition (onset)	180°C (20°C/min)
particle dimensions	spheres
incompatibilities	isocyanates

ADN Propellants

Several programs at Thiokol have examined the viability of ADN in solid propellant formulations. Initial work was performed on IR&D and indicated that ballistic and performance advantages could be realized employing ADN in high energy propellants. Later work has focused on elaborating the performance, ballistics, mechanical properties, hazards, and aging properties of both high energy and booster formulations involving ADN. Initial efforts were funded by BMDO/ONR and more recent efforts supported by the

Integrated High Payoff Rocket Propulsion Technology (IHPRPT) -
Alternate Oxidizers and Fuels Program under direction of the Air Force Research Laboratory. In combination with other standard propellant ingredients, formulations with significant quantities of ADN have demonstrated acceptable ballistics and mechanical properties. However, the hazards properties have not been acceptable at the higher levels of ADN incorporation. Current results indicate that employment of ADN as a ballistic modifier would be the most practical application for this material. Because of the attractive nature of ADN in booster propellants (ignoring for the moment the hazards properties), additional work is planned to determine the upper limit of ADN incorporation that does not compromise hazards requirements.

Demilitarization of ADN Propellants

Several of the properties mentioned earlier for ADN (high water solubility, moderate sensitivity to impact and friction) allow for the employment of the environmentally acceptable method of high pressure water washout for the demilitarization of ADN-containing propellants. High pressure water washout of solid propellants has a long and successful history at Thiokol. Coupling ~~of~~ this technology with recycling ~~of~~ the washout water and either ingredient recovery or reuse of reclaimed propellant in commercial mining explosives yields a demilitarization method that produces little or no hazardous waste. IR&D laboratory studies at Thiokol indicate

that ADN and ADN-containing propellants will be amenable to the above mentioned technologies.

The Future of ADN Propellants

The development of ADN as a viable propellant ingredient has progressed significantly during the last several years. Based upon current results, Thiokol and others have identified applications for ADN in solid propellants as an additive to improve performance and ballistics. However, the hazards classifications of propellants which employ ADN as the main oxidizer are currently unacceptable for use in booster propellants. Additional areas still remain to be explored to determine if this limitation can be overcome.

Acknowledgments

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References

¹ "Environmentally Sound Processing Technology" Workshop, held at the 1995 JANNAF Safety and Environmental Protection Subcommittee Meeting, San Diego, California, July, 1995.

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² Bennett, R. R.; McDonald, A. J. "The Environmental Impacts of Acids and Halogens From Rockets," presented at the 1995 JANNAF Propulsion and Subcommittee Joint Meetings, Tampa, Florida, December, 1995.

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³ Munson, W. O. "Status of Thiokol's R³ Demilitarization Projects," presented at the 1998 Life Cycles of Energetic Materials Conference, Fullerton, California, March, 1998.